STAR Near Future Physics Program

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Outline

(1) Introduction

(2) Recent Results from STAR

(3) Near Future Physics Program

Physics Goals at RHIC

RHIC

Au+Au, Cu+Cu, d+Au, p+p collisions at 200 – 5 GeV

Polarized p+p collisions at 200 & 500 GeV

p+p, d+Au pp2pp

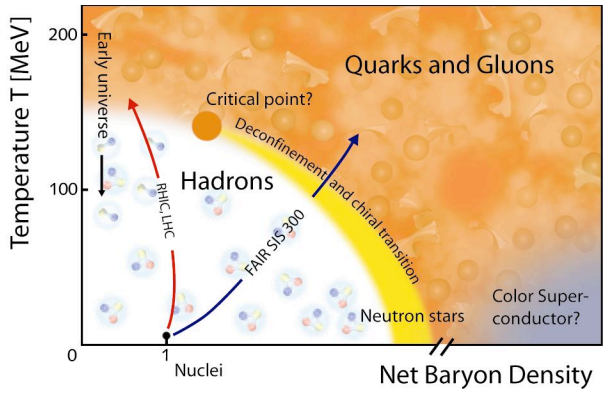
- Identify and study the property of matter (EOS) with partonic degrees of freedom.

- Explore the QCD phase diagram.

- Study the origin of spin in *p*.

- Investigate the physics at small-*x*, gluon-rich region.

STAR Physics Focus

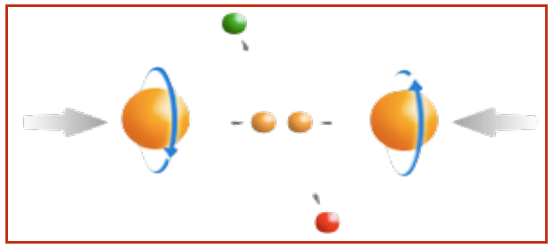


1) At 200 GeV top energy

- Study ***medium properties, EoS***
- pQCD in hot and dense medium

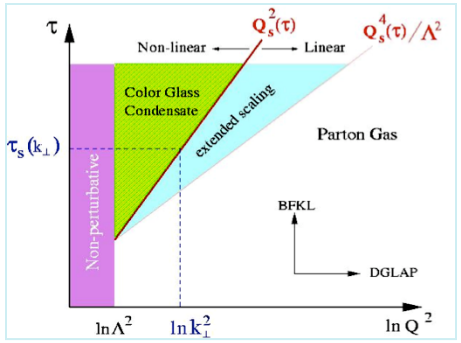
2) RHIC beam energy scan

- Search for ***critical point***
- Chiral symmetry restoration



Polarized spin program

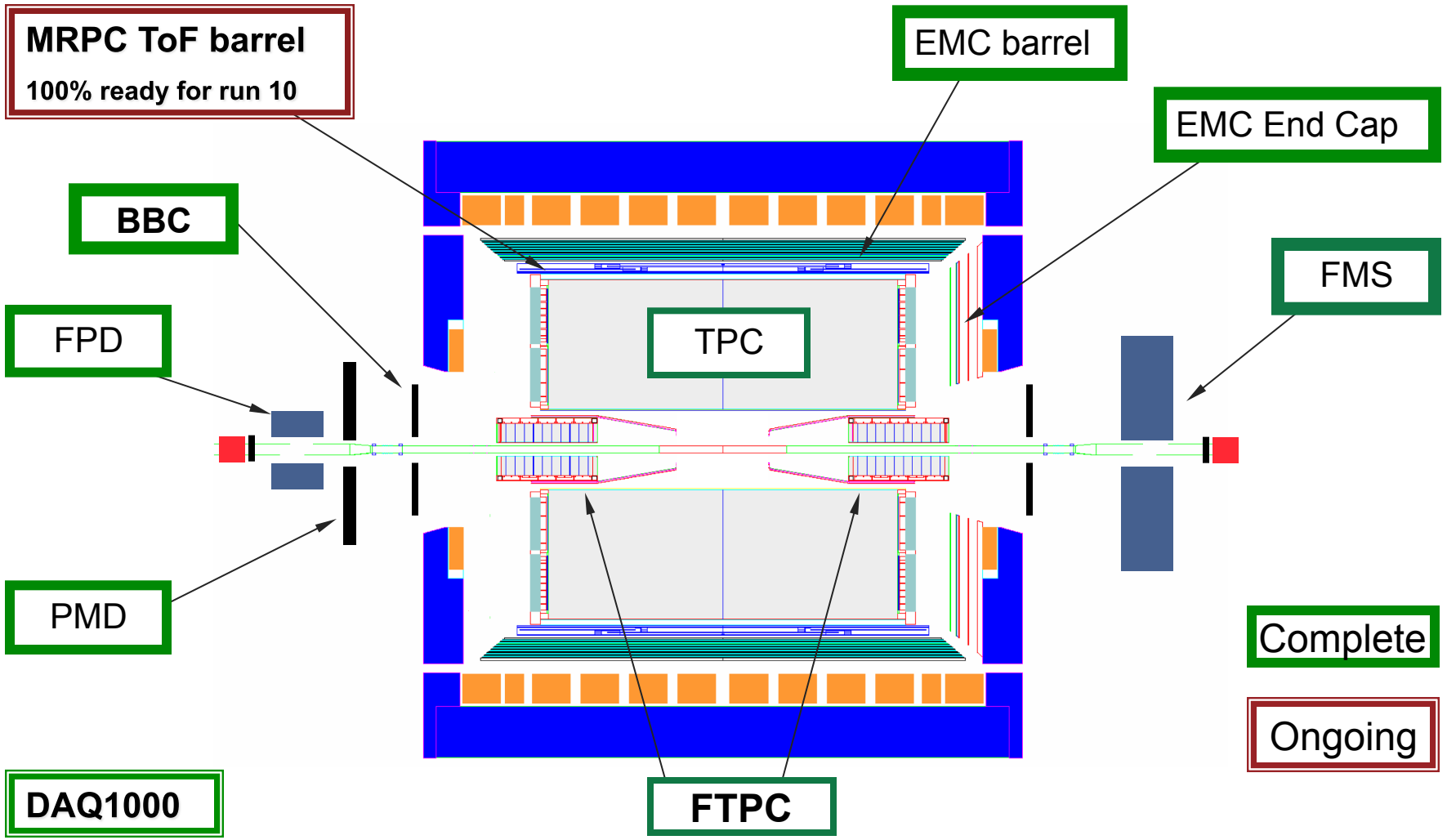
- Study ***proton intrinsic properties***



Forward program

- Study low-x properties, search for ***CGC***
- Study elastic (inelastic) processes (pp2pp)
- Investigate ***gluonic exchanges***

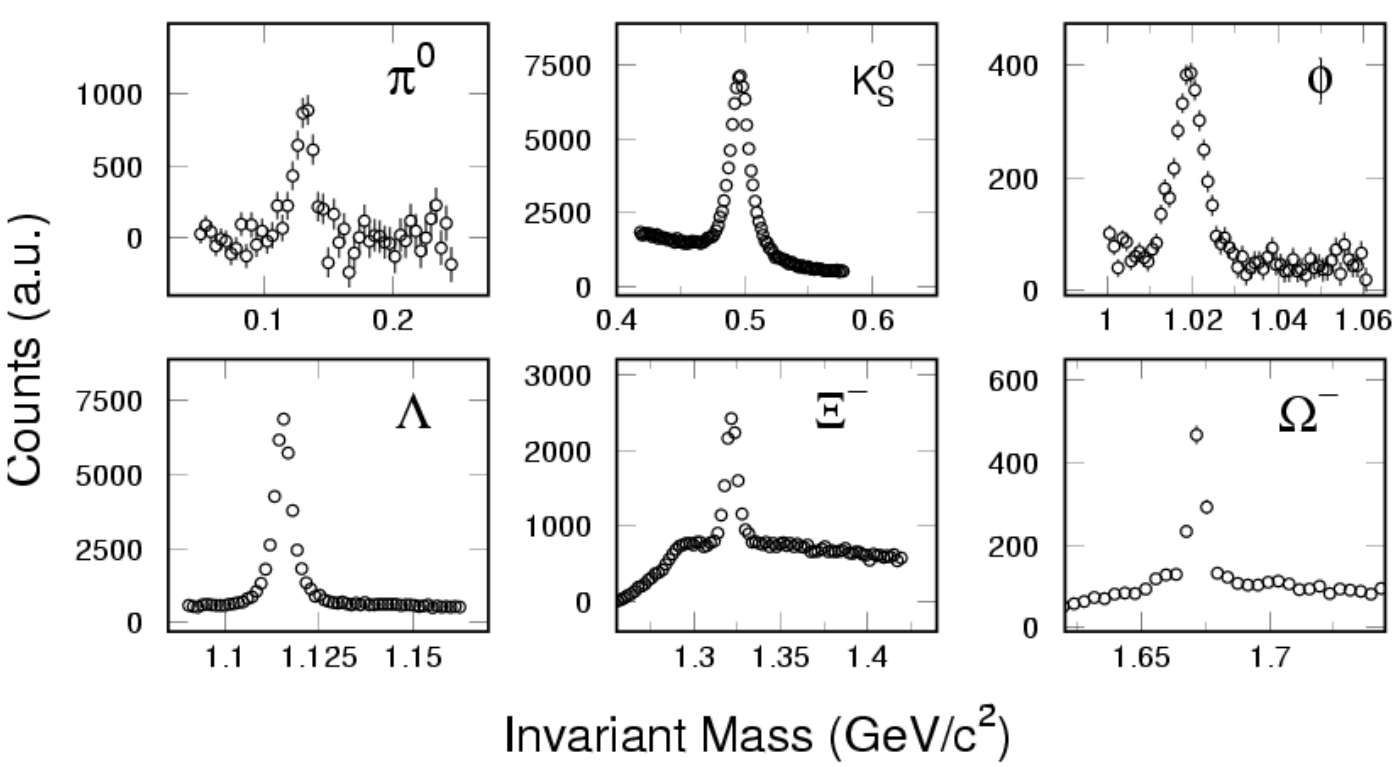
STAR Detector (current)

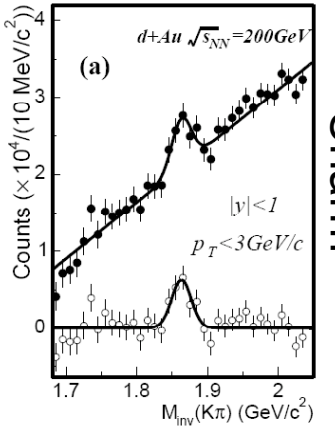


Full azimuthal particle identification!

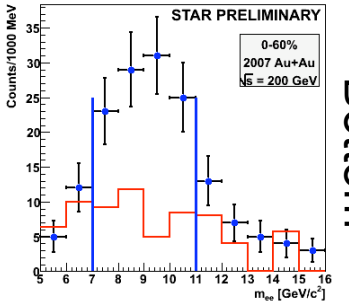
*γ, e, π, **ρ**, K, **K***, p, **φ**, Λ, Δ, Ξ, Ω, D, Λ_C, **J/ψ**, **Υ** …*

Particle Identification (ii)





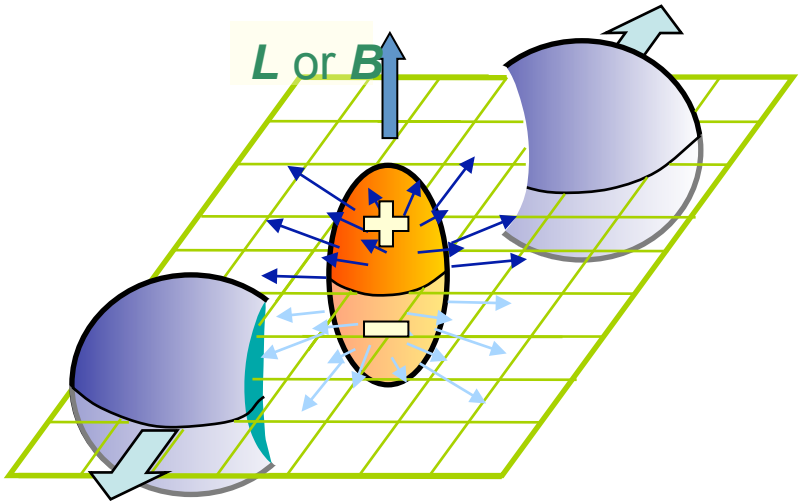
Charm

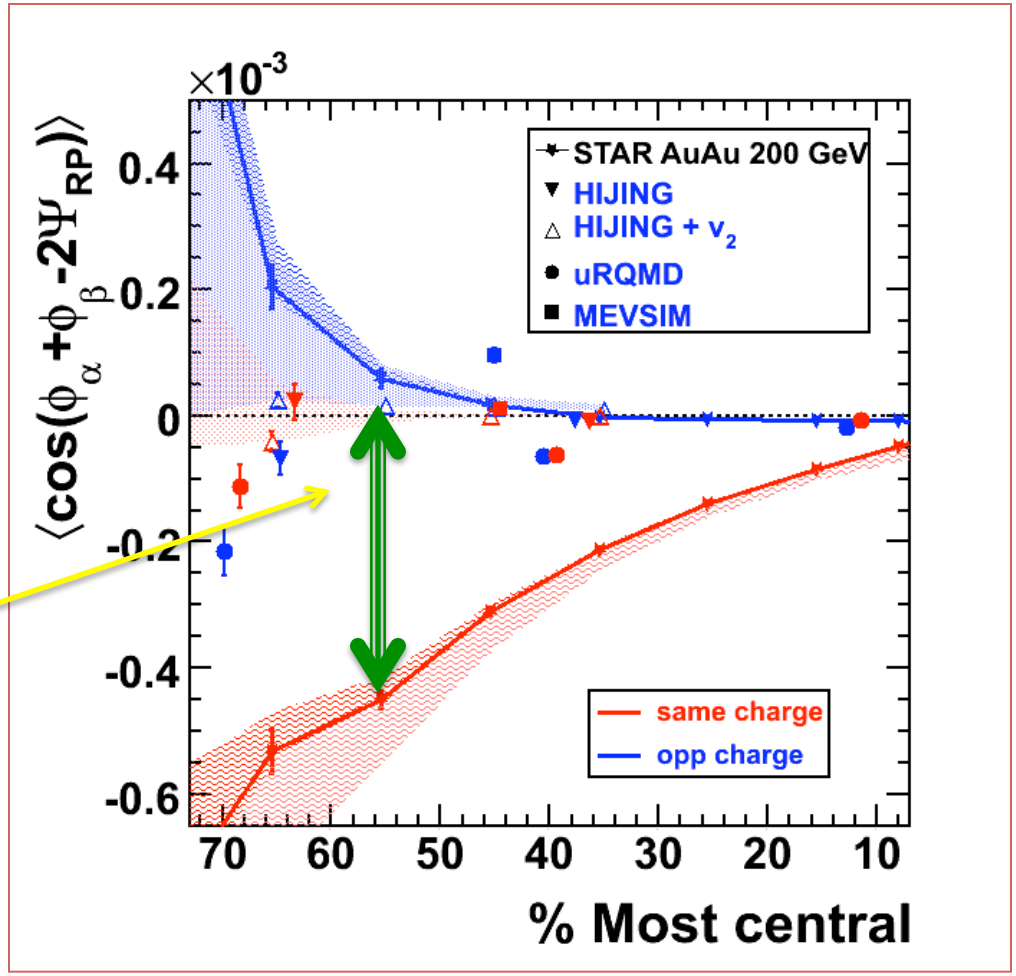


Bottom

Reconstruct particles in full azimuthal acceptance of STAR!

Search for Parity Violation …



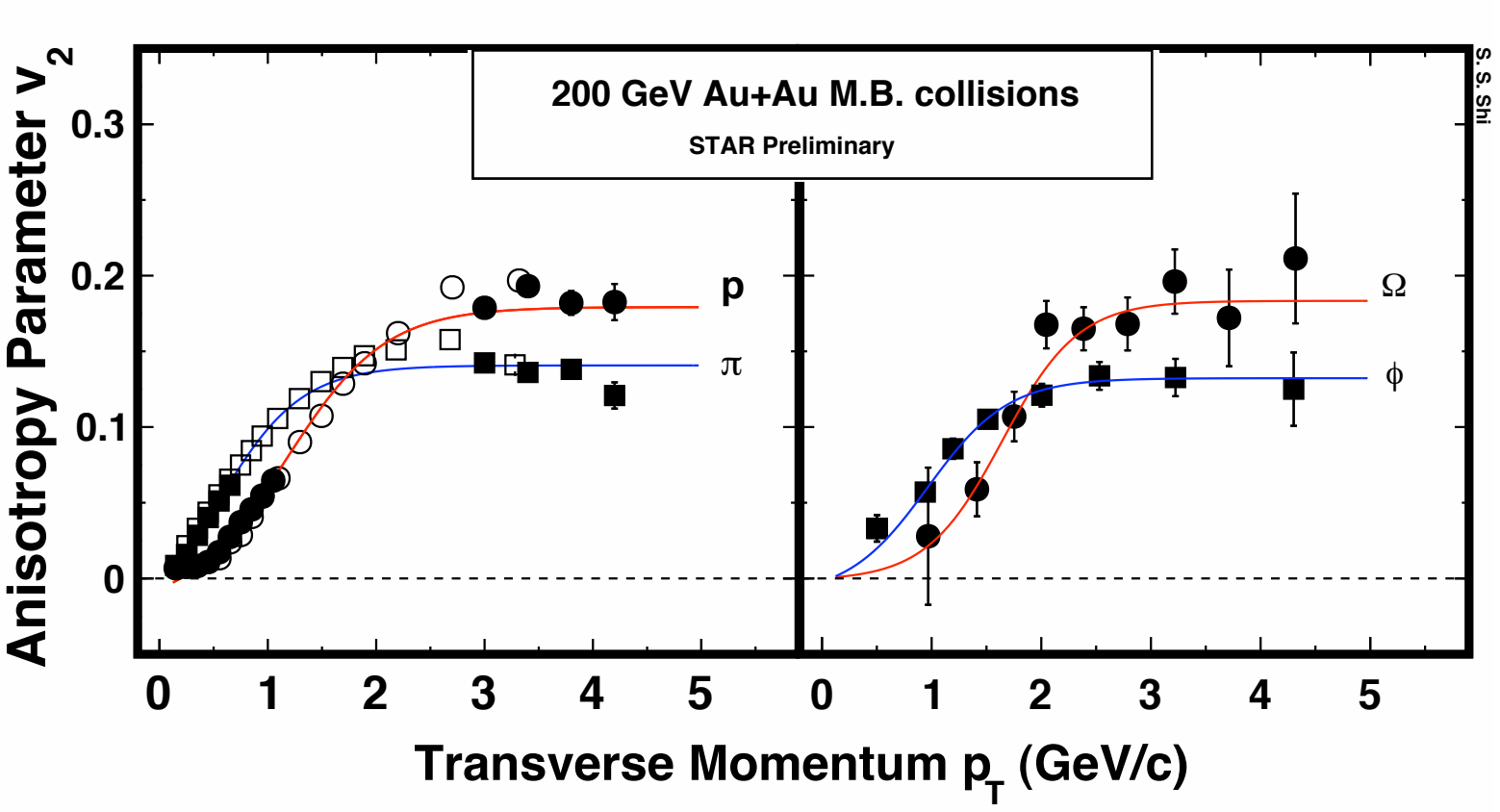


The separation between the same-charge and opposite-charge correlations.

- Strong EM fields
- De-confinement and Chiral symmetry restoration

Sergei Voloshin, QM09

New v_2 Results (Run7)

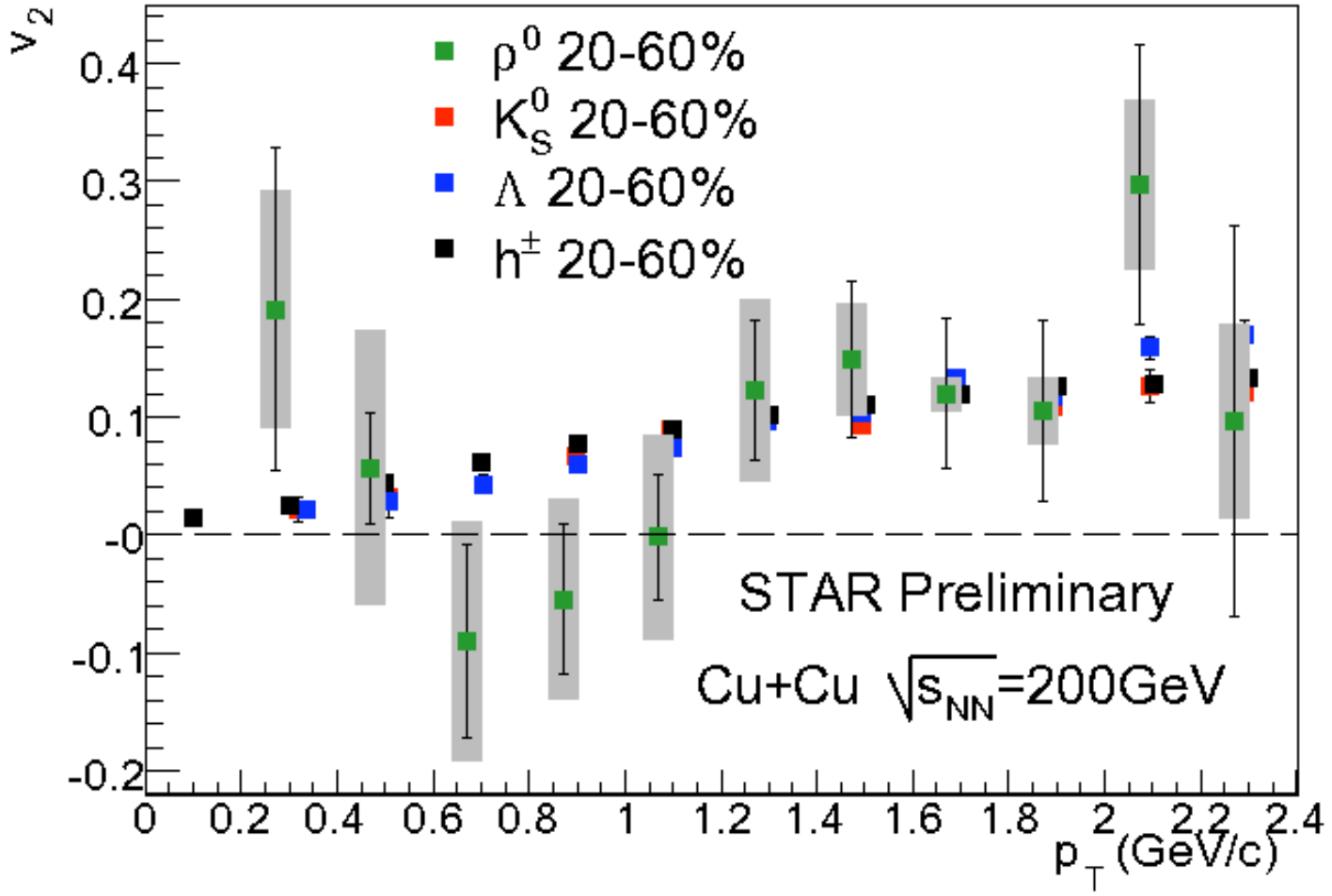


Run7 data, strangeness flow =>

Final word on partonic collectivity at RHIC!

Shusu Shi, QM09

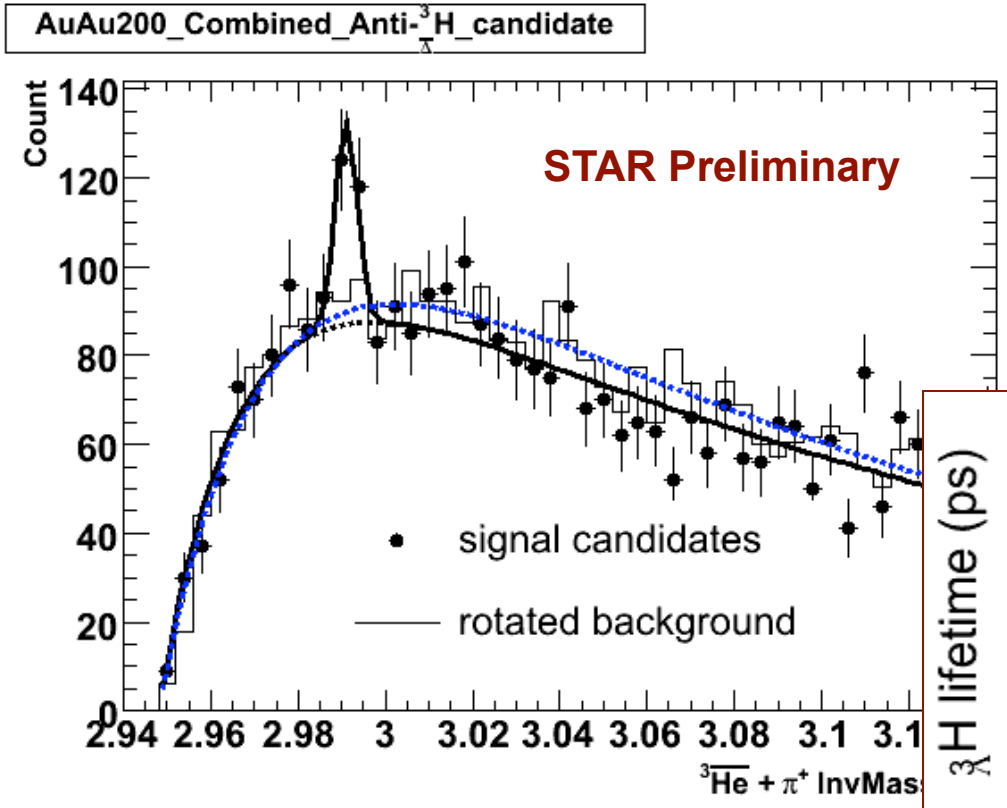
Event Anisotropy for ρ^0-meson



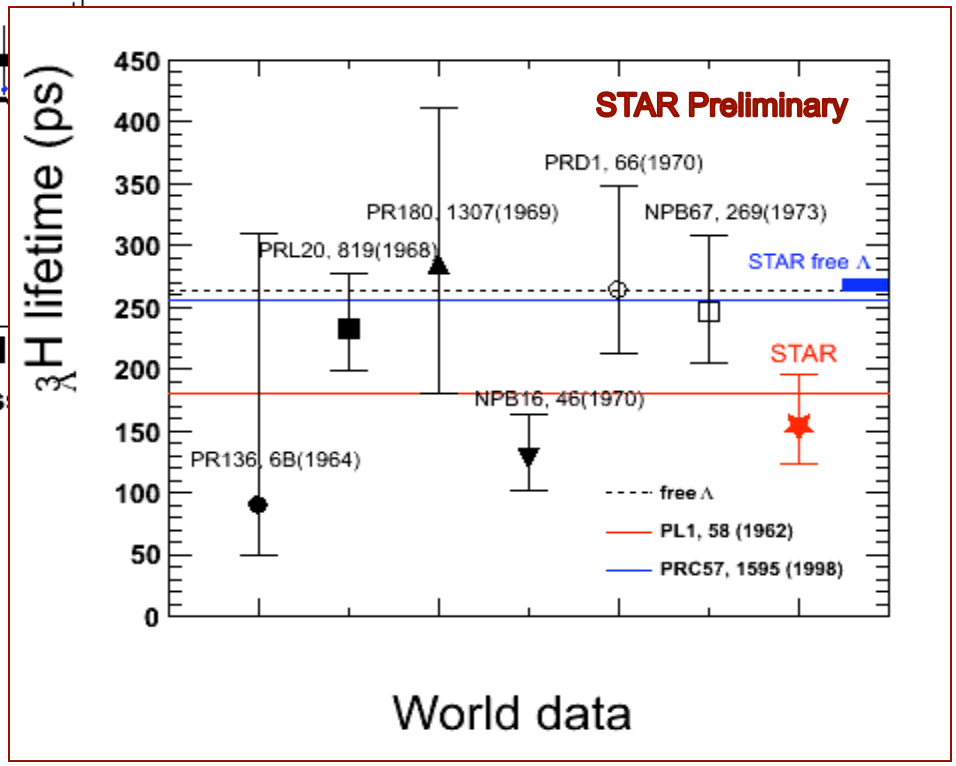
- **First measurement of ρ^0: v_2 ~ 13 ± 4%** (p_T >1.2 GeV/c).
- Physics discussion will depends on future results with ToF.

Particia Fachni, QM09

First Observation of $^{3}_{\Lambda}\overline{H} \rightarrow {}^{3}\overline{He} + \pi^{+}$



200 GeV Au+Au collisions at RHIC



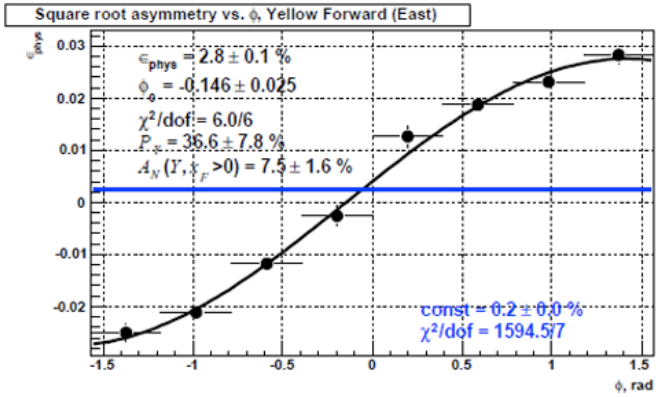
New!

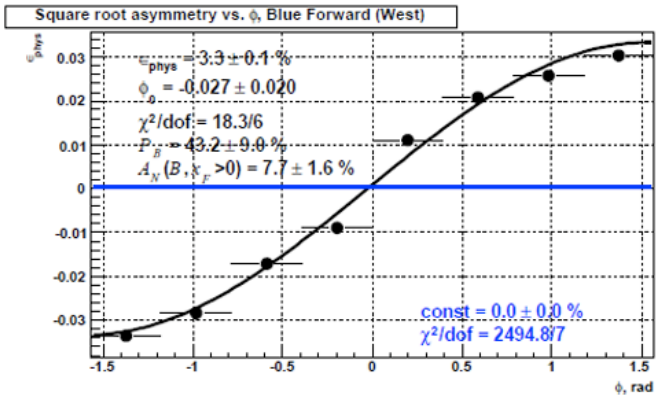
More data with full ToF needed!

Jinhui Chen, QM09

Local Polarity from 500 GeV p+p

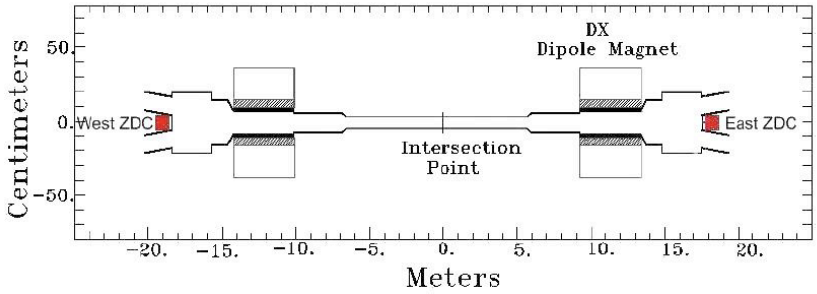
Transverse polarization





ZDC Single Spin Asymmetry (fill 10348)

Thu Mar 12 07:19:11 2009



In 500 GeV p+p collisions, ZDC has been used for the polarization measurements.

sQGP and the QCD Phase Diagram

In 200 GeV Au+Au collisions at RHIC, strongly interacting matter formed:

- **Jet energy loss: R_{AA}**
- **Strong collectivity: v_0, v_1, v_2**
- **Hadronization via coalescence: n_q-scaling**

Questions:

Is thermalization reached at RHIC?

- **Systematic analysis with dN/dp_T and dv_2/dp_T results…**
- ***Heavy quark measurements***

When (at which energy) does this transition happen?
What does the QCD phase diagram look like?

- ***RHIC Beam Energy Scan***

High-Energy Nuclear Collisions

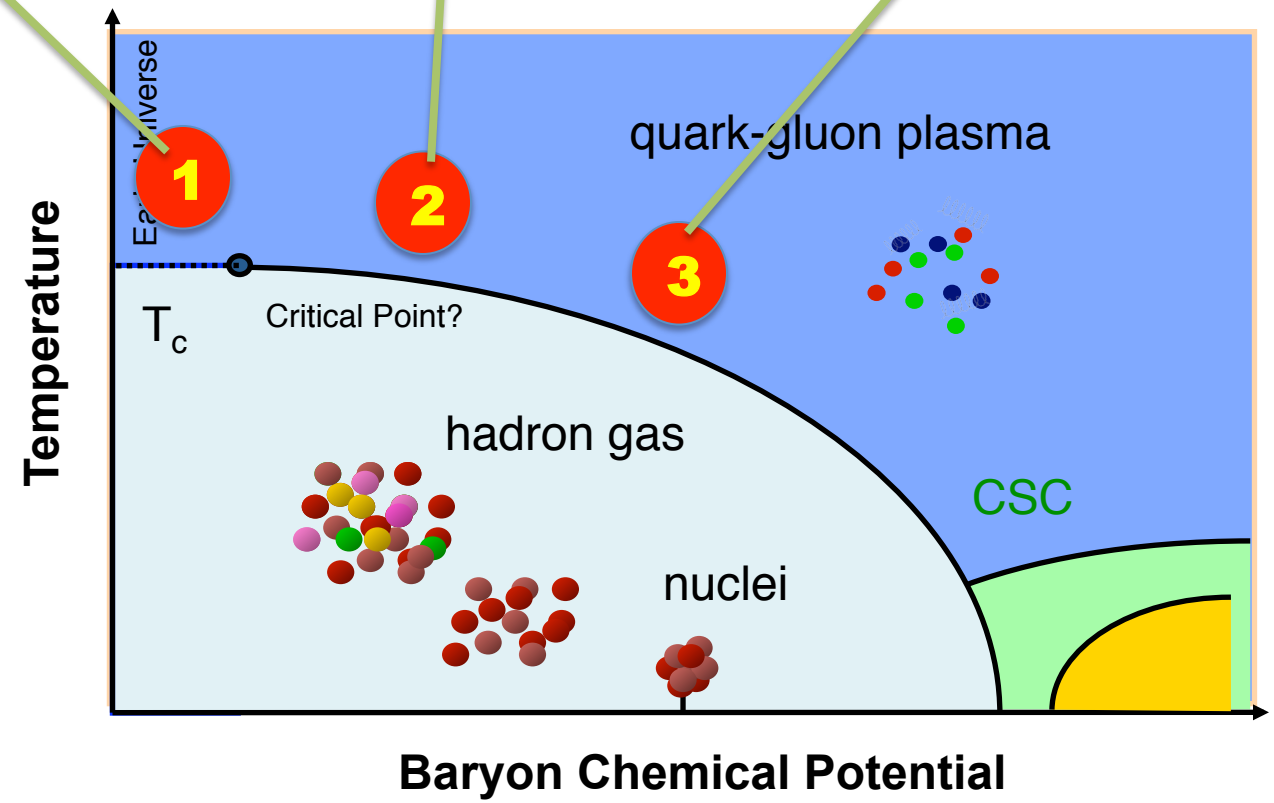
1 **Energy Frontier** — High T_i — *LHC, RHIC*

2 **Density Frontier** — T_E — *RHIC, FAIR*

3 **Baryon Density** — 1st order p.b. — *FAIR, NICA, CSR*

High-Energy Nuclear Collisions:

Explore the QCD landscape, structure of the matter with partonic degrees of freedom.



STAR Mission

STAR collaboration physics program:

- **Best** positioned for Exploring the QCD phase diagram
- **Excellent** for precision measurements
- **Great** potential for new discoveries

Complementary to ALICE at LHC at higher energy
Complementary to CBM at FAIR at lower energy

Physics focuses:

(1) Light quark thermalization:

heavy quark collectivity

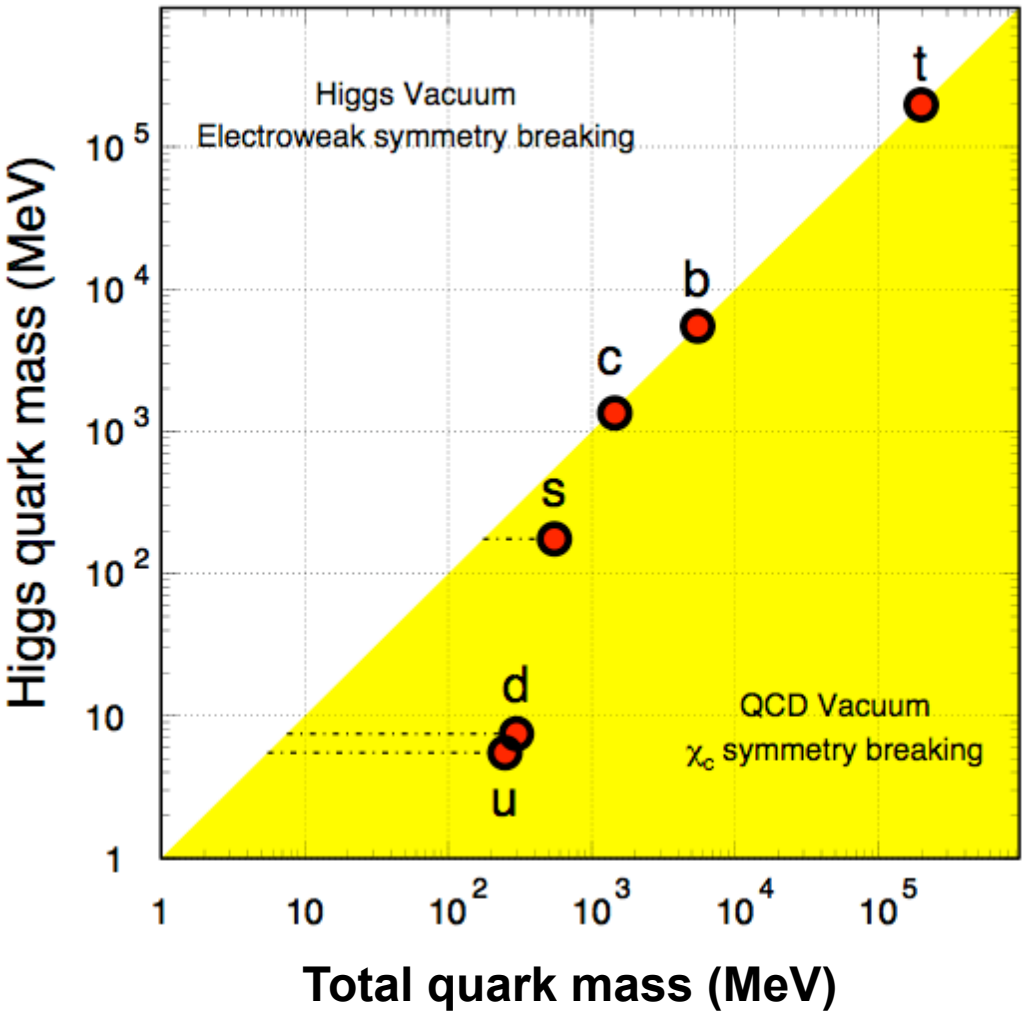
(2) QCD critical point and phase boundary:

n_q scaling in v_2, net-p Kurtosis

(3) Chiral physics:

di-electron (*mass, width), continuum, σ, v_2, R_{AA}*

Quark Masses



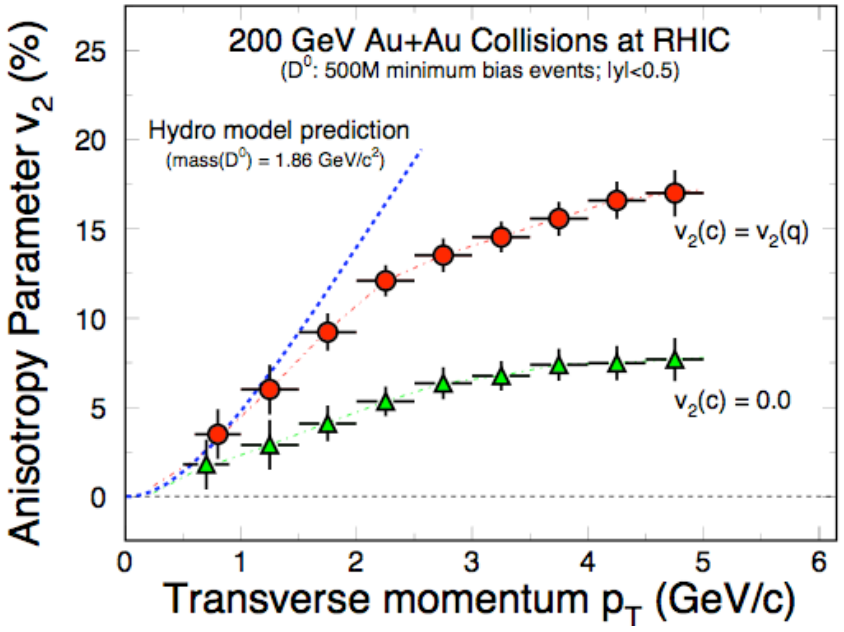
1) Higgs mass: electro-weak symmetry breaking. (current quark mass)
2) QCD mass: Chiral symmetry breaking. (constituent quark mass)

⇨ New mass scale compared to the excitation of the system.

⇨ Important tool for studying properties of the hot/dense medium at RHIC.

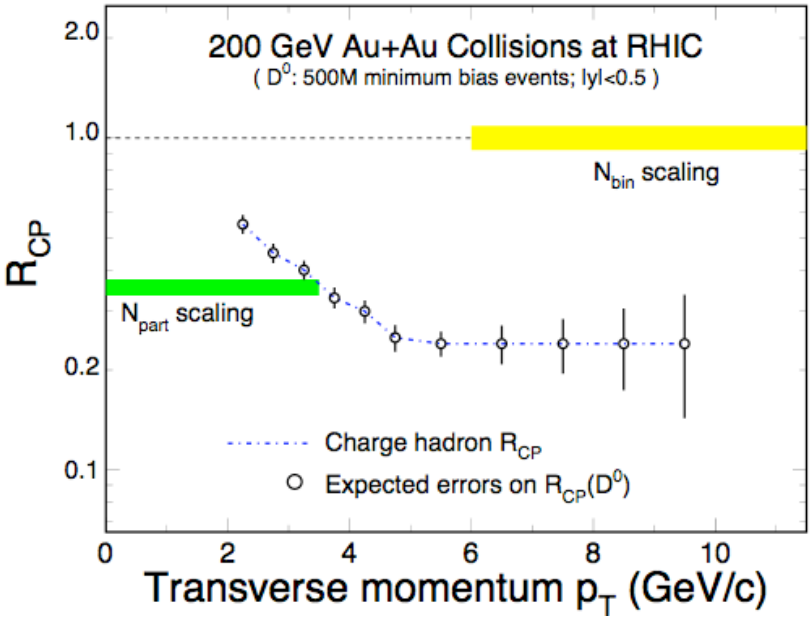
⇨ Test pQCD predictions at RHIC.

Charm Hadron v_2 and R_{AA}



- 200 GeV Au+Au m.b. collisions (500M events).
- Charm hadron collectivity ⇨ drag/diffusion constants ⇨

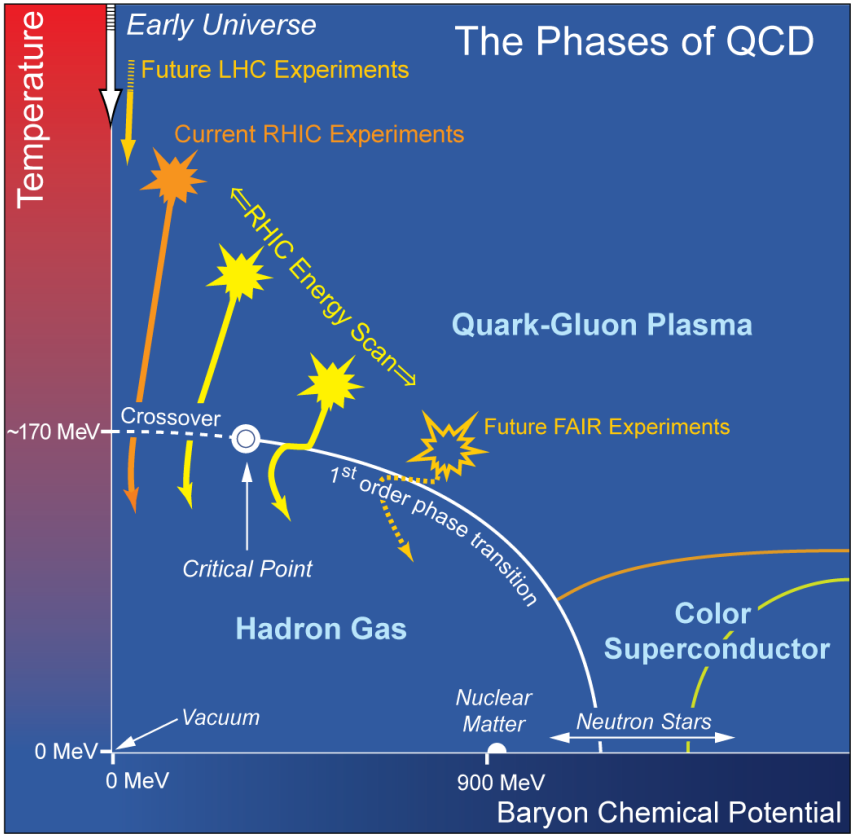
Medium properties!



- 200 GeV Au+Au m.b. collisions (|y|<0.5 500M events)
- Charm hadron R_{AA} ⇨

- Energy loss mechanism!
- QCD in dense medium!

The QCD Phase Diagram



STAR's plan:

run10: RHIC Beam Energy Scan
run11: Heavy Quark measurements

- LGT prediction on the transition temperature, T_c ~ 170 MeV.

- LGT calculation, universality, and models point to the existence of the critical point on the QCD phase diagram* at finite baryon chemical potential.

- Experimental evidence for either the critical point or 1st order transition is important for our knowledge of the QCD phase diagram*.

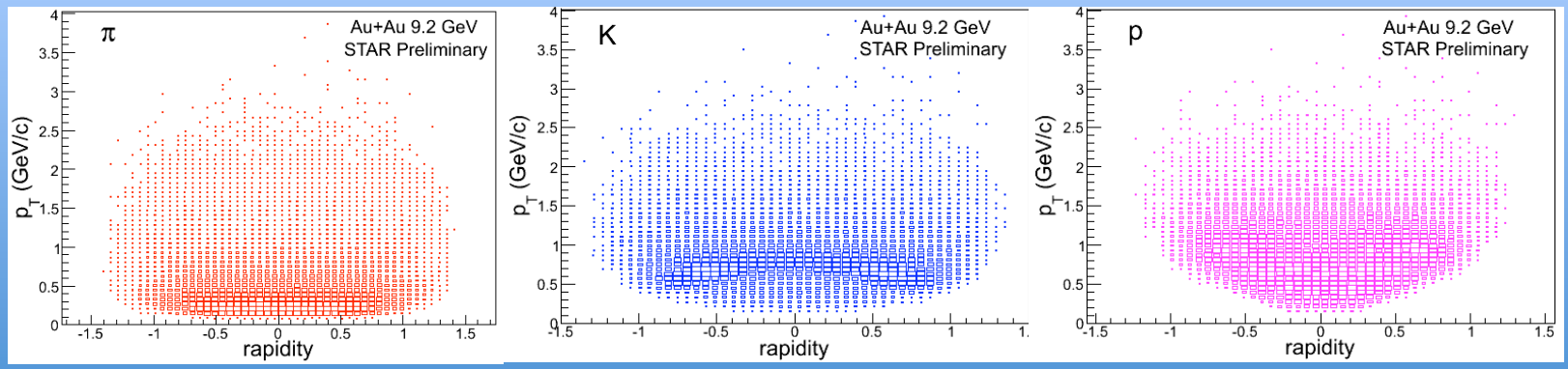
*** Thermalization is assumed**

*Stephanov, Rajagopal, and Shuryak, PRL **81**, 4816(98)*
*Rajagopal, PR **D61**, 105017 (00)*
http://www.er.doe.gov/np/nsac/docs/Nuclear-Science.Low-Res.pdf

Collider Acceptance

Collider Mode STAR

$\sqrt{s_{NN}}$ = 9.2 GeV Au+Au Collisions at RHIC

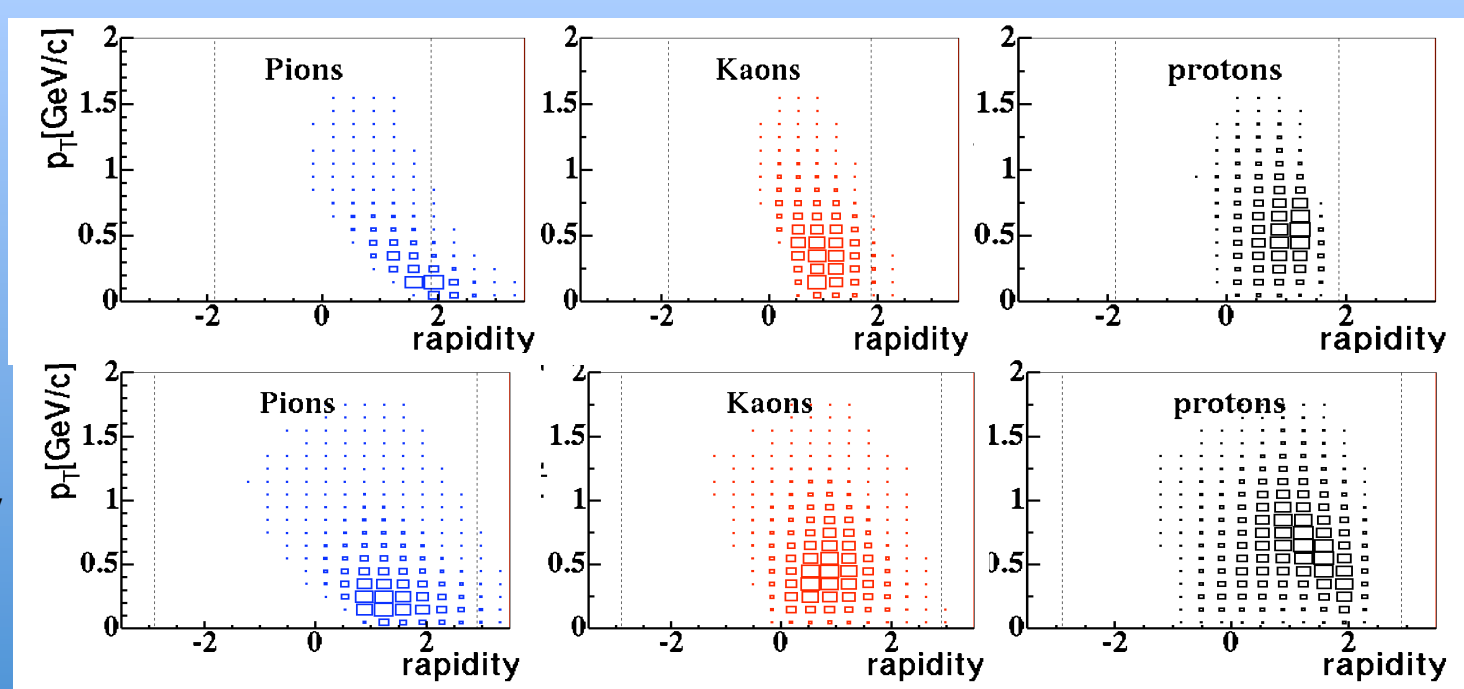


Fix-target Mode NA49

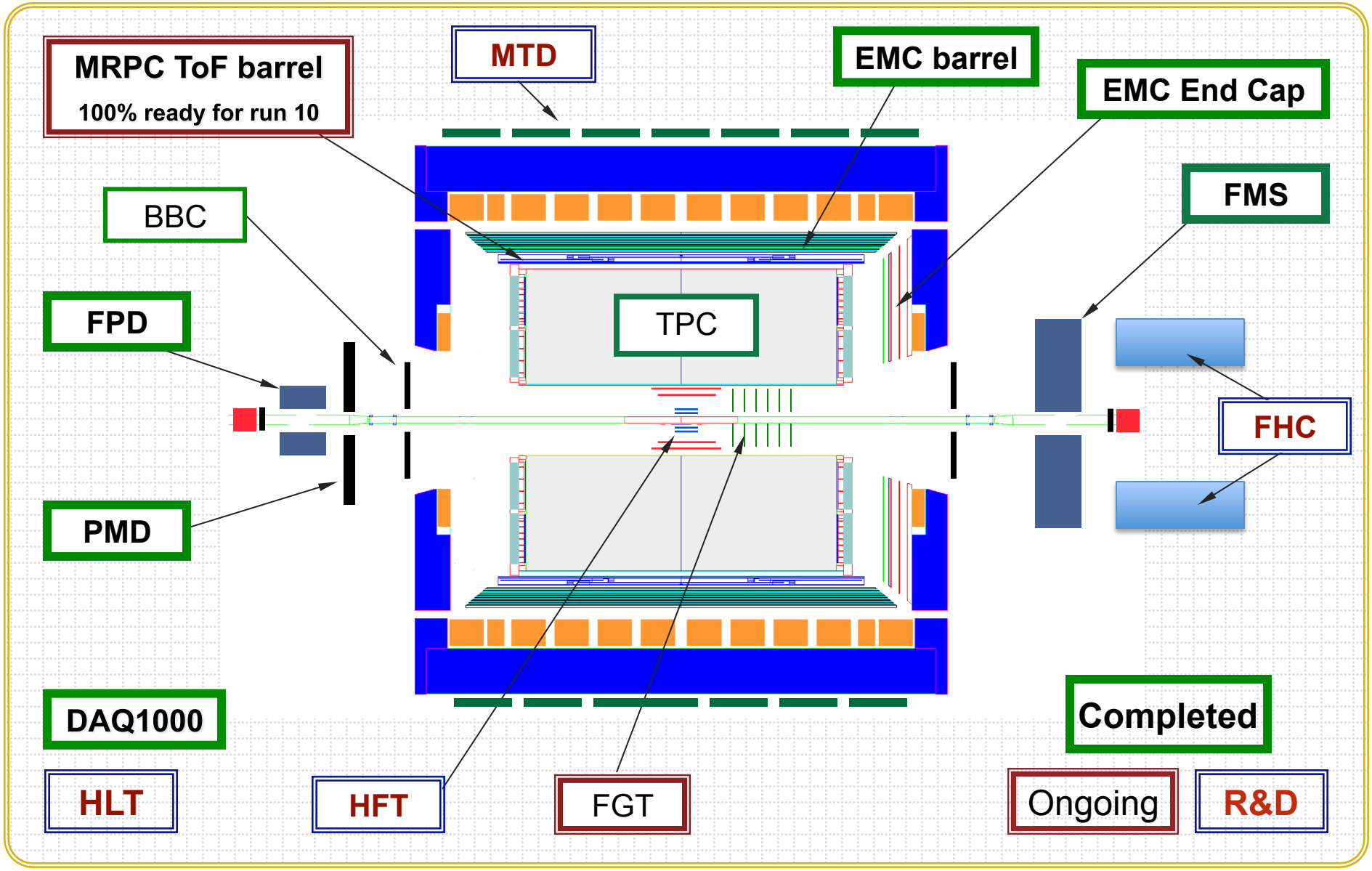
$\sqrt{s_{NN}}$

6 GeV

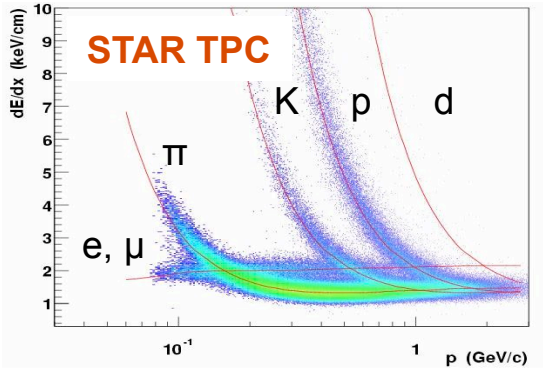
17 GeV

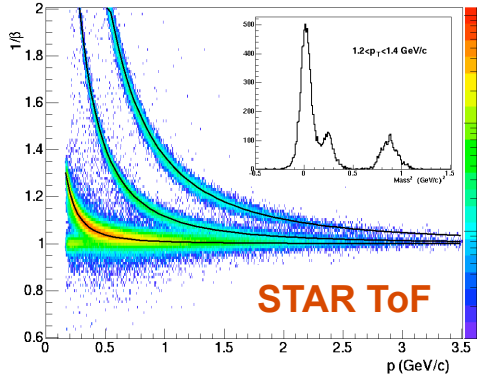


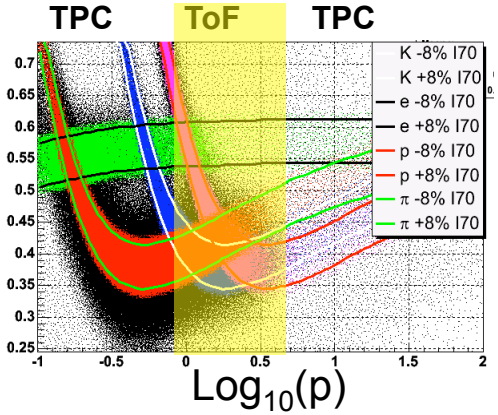
STAR Detector

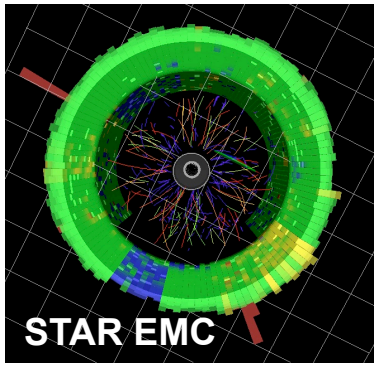


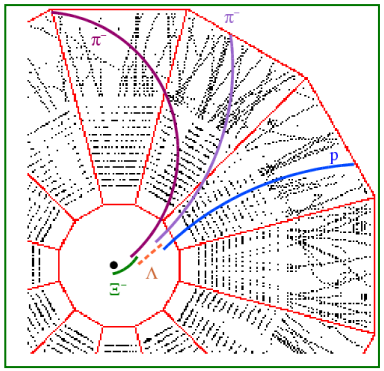
Particle Identification at STAR

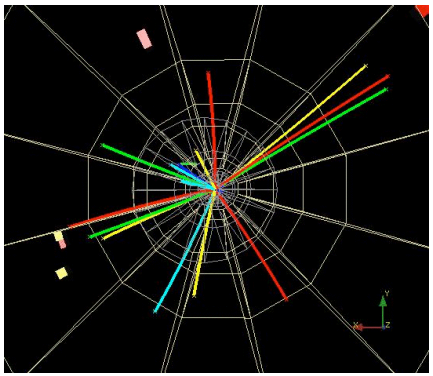


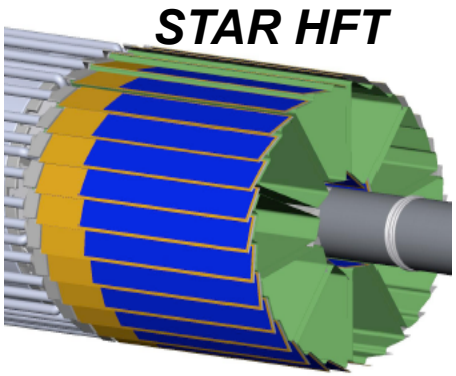








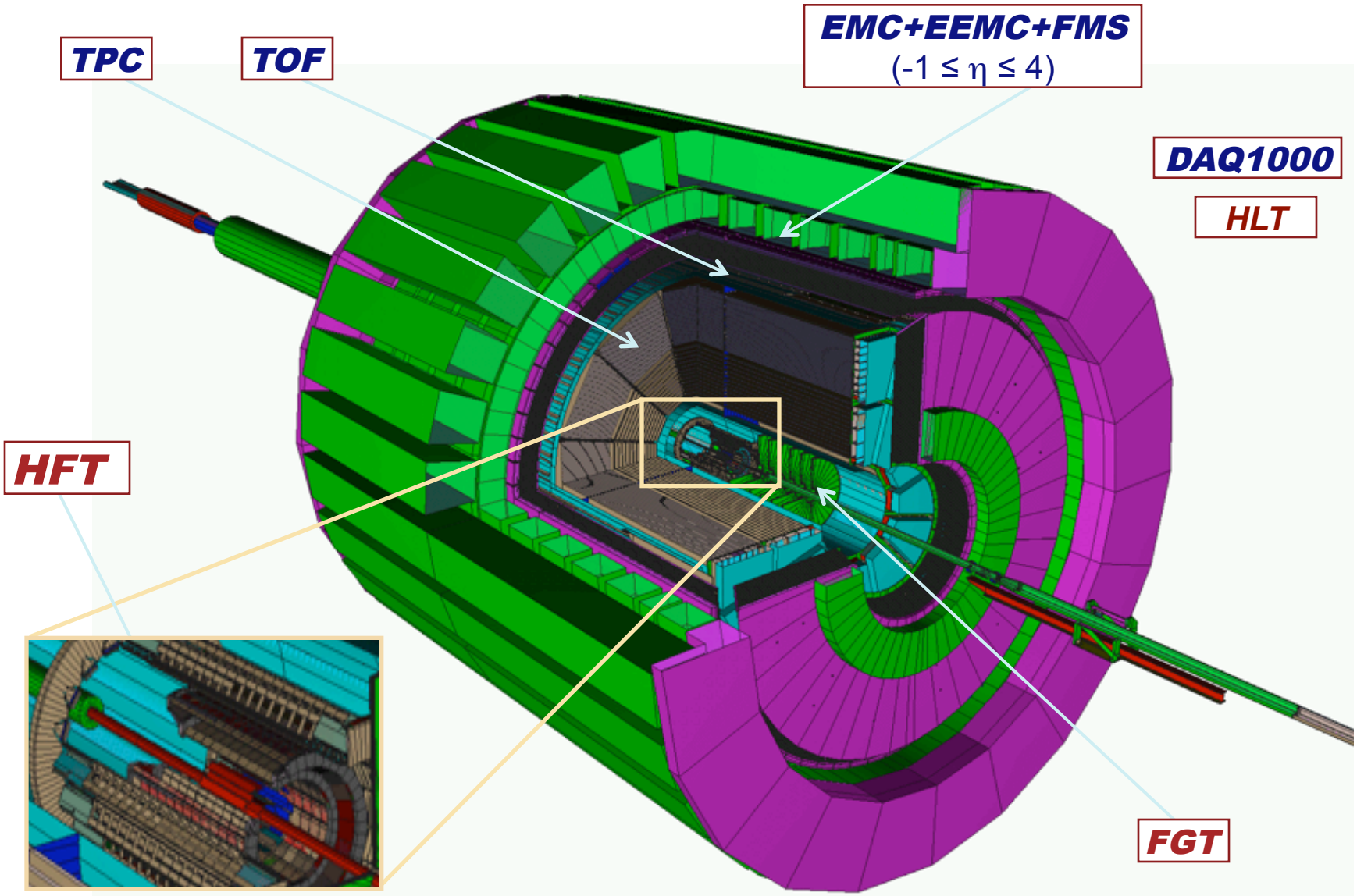




Neutral particles **Strange hyperons** **Jets** **Heavy Quark Hadrons**

Multiple-fold correlations among the identified particles!

STAR Detectors: *Full 2π particle identification!*

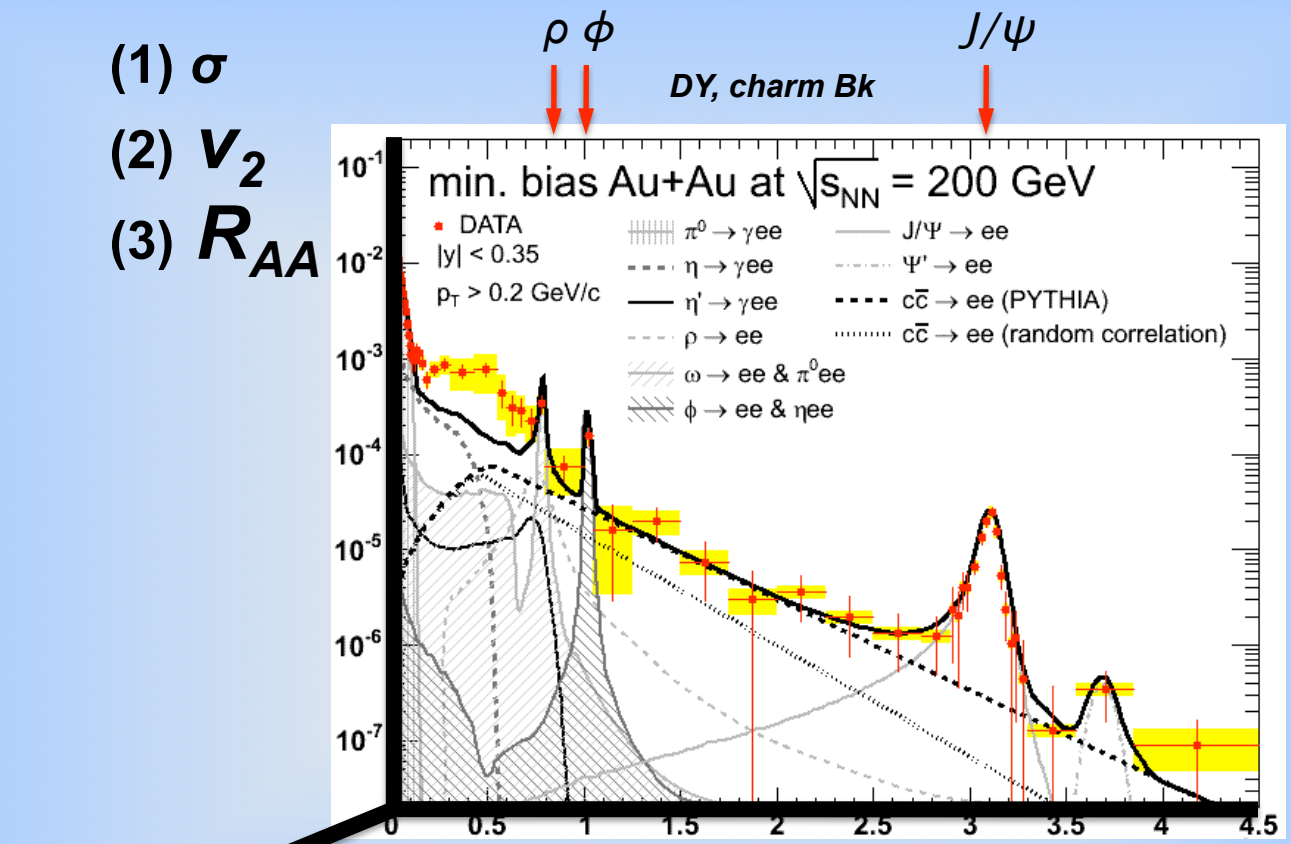


The di-Lepton Program

(1) σ

(2) v_2

(3) R_{AA}



✓ **Chiral Symmetry Restoration**

✓ **Direct Radiation from The Hot/Dense Medium**

*** ToF Crucial for the physics.**

STAR Physics Focus (HI)

1) Heavy Quark Distributions

   - Heavy flavor collectivity, light flavor thermalization

2) Beam Energy Scan

   - QCD critical point and phase boundary

3) Di-lepton (electrons)

   - Signature of Chiral transition

4) U+U Collisions

   - Test of thermalization

Exciting STAR physics program!